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WISCONSIN VERSUS ILLINOIAN AGE SOILS: THEIR EFFECT ON AGRICULTURAL TYPES IN OHIO[1]

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Abstract. A portion of the area covered by Wisconsin and Illinoian age till plain soils in Ohio was studied to determine the influence of these contrasting adjacent soil regions on farming operations and agricultural types. The study indicated that the Wisconsin age soil region is a corn-livestock agricultural region that emphasizes corn production on highly productive soils. The Illinoian age soil region, however, is a mixed farming agricultural region that emphasizes soybean production to help overcome the limitations of the much less productive soils. The difference in the soils does affect differences in the agricultural types imposed on them.

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A primary objective of agricultural geography is the study of the spatial variation in agriculture. The attempt to categorize and describe variations of agriculture is a continual challenge (Spencer and Stewart 1973). Often spatial variations have been discussed in a regional context (Baker 1926, Weaver 1954, and Coppock 1964) and most of these regional agricultural studies have been restricted to the study of a single region or to the regional pattern of single features. Thus, there appears to be a need to reexamine farming and agricultural types on a comparative basis between contrasting regions.

Approaches to the question of the relationship between agriculture and the physical environment have been varied and changing over the past 50 years in agricultural geography. Commercial agriculture is sensitive to even small physical advantages or disadvantages of a particular region. Land use has long been patterned in close relation to variations in topography, soils, temperature, and moisture (Baker 1921). The best land for agricultural production is that which is most fertile and most easily cultivated and shows higher yields than less fertile land. Physical factors may be important in influencing differences in agricultural types within agricultural regions. In attempts to discern the spatial patterns of these so called "better lands," a number of research studies have separated the physical environment into its component parts such as climate (Rose 1936, Weaver 1943, and Visher 1940) and topography (Hidore 1963).

Research into the influence of soils on agriculture patterns has been less intensive. Some geographers have been concerned with optimum soils areas for individual crops; however, few studies have given priority to soils. Many geographers apparently prefer to consider soils as a secondary factor in agricultural processes (Gregor 1970).

The principle of intensification of production on better soils lends itself to a regional geographic approach to contrasts between natural fertility and soil productivity. Relatively little recent work has been reported on the interaction between soils and agricultural patterns (Mausel 1971) and a need exists for more detailed work on the relationships between soils and agricultural types in a spatial framework. The purpose of my study was to determine the effect of soils in 2 contrasting adjacent soil regions on the agricultural types in each region. The agricultural types were broken down into their component parts and examined factor by factor to determine the extent

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and degree of contrast between the adjacent soil regions.

STUDY AREA—SOIL REGIONS

The study is located in Clinton and Warren Counties, Ohio (figure 1). This particular area was chosen for analysis because of the apparent contrasting soils found in adjacent regions. The boundary between the adjacent regions divides both counties, and as a result, county land use data does not reflect the contrast. My study is restricted to the till plain portions of the regions that could be studied and to sample farm groups on the till plains of slight topographic relief with slopes less than 5% in order to more intensively examine the relationships under investigation. Thus, a uniform climate, forest vegetation, near level topography, and till plain landform were constant factors in the area chosen for study.

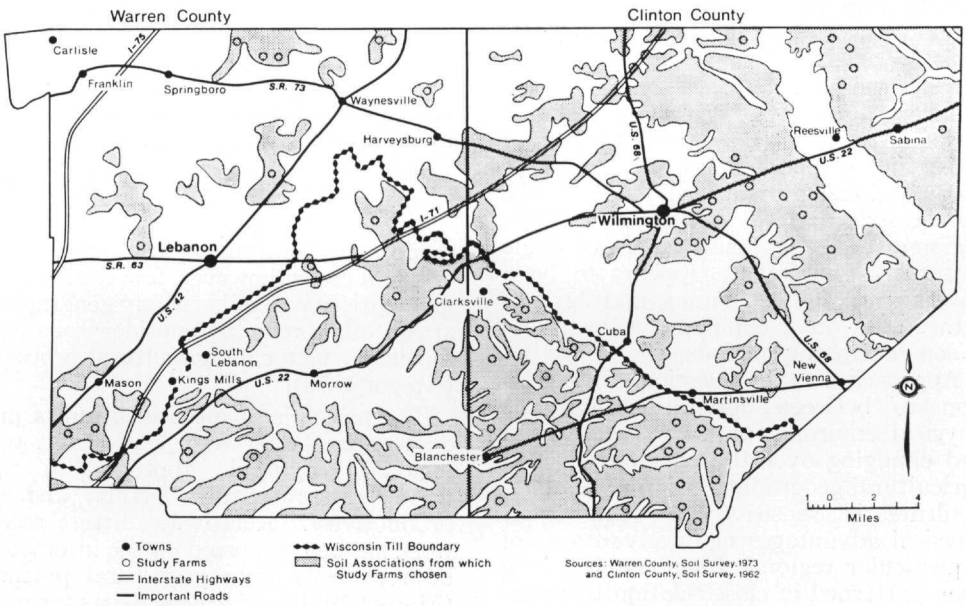

FIGURE 1. Map of Clinton and Warren counties showing study area.

The major factor contributing to soil differences in the study area is the soil parent material. One parent material is Illinoian age till, which has been altered greatly by deep leaching of carbonates and other weatherable minerals. The other parent material is a younger Wisconsin age till, which was less altered by weathering than the Illinoian till. Both tills have been modified by a 50 cm to 100 cm loess cap. The Wisconsin till-loess soil, however, can be considered more naturally fertile than the Illinoian till-loess soil (Garner *et al* 1973) because the loess was weathered to a different degree in response to the contrasting nature of the underlying tills. The boundary between the parent materials is often abrupt with a sharp drop from gently sloping lands on the younger till to a lower, near level surface on the older till. Both tills are similar in texture, mineralogy, and structure, but the age of the tills and the degree of soil development on them varies markedly. The relative age of the tills and the relative development of soils are the key factors of contrast between the 2 regions of the chosen study area.

The Illinoian age "claypan" Alfisols (Fragiaqualfs) are known locally as the "crawfish lands" or the "pin-oak flats" (Garner and Meeker 1962 and Garner *et al* 1973) and are characterized by a firm, compact mottled silty clay loam fragipan B horizon that retards air and water movement. The Clermont and Avonburg series are very strongly acid and

have low amounts of nitrogen, phosphorus, and potassium available for crop production. They need lime, fertilizer, and organic matter to be at all productive (Garner *et al* 1973).

The Wisconsin age Alfisols (Ochraqualfs) and Mollisols (Argiaquolls) of the study area are much more naturally fertile soils than the "claypan" soils to which they are compared (Garner and Meeker 1962). The Brookston, Fincastle, Ragsdale, and Reesville series are moderately to slightly acid and have a higher productive capacity (Garner *et al* 1973). These soils are well supplied with potassium and phosphorus and have moderate to high levels of organic matter. Drainage is imperfect to poor but, unlike the Illinoian age soils, tile drains work well at reducing excess water.

METHODS

A number of factors associated with agricultural types generally found in the Midwest were investigated to determine the degree of contrast of each individual factor between the contrasting soil regions and to determine which factors varied significantly in relation to differences in the soils. A group of 25 farms was selected randomly from the soils on the near level till plains from each of the 2 regions chosen for the study using a system of grid coordinates and random numbers to locate sample farms. Each farm selected was located on soils indicated above as being part of the study area based on the soil survey map sheets for the 2 counties, functioning as a farming operation, and worked by a full-time farm operator. Farms were restricted to the soil series listed above; however, no attempt was made to measure the acreage of each different soil.

Soil data were collected for each farm selected. Basic data came from information in the county soil surveys and survey map sheets (Garner and Meeker 1962 and Garner *et al* 1973). More detailed data on pH, cation exchange capacity, percent base saturation, nitrogen, phosphorous, and potassium content were collected from analysis reports of soil samples sent to the state soil testing laboratories. Soil data were incorporated into an index giving the value of each soil type relative to other soils for general agricultural purposes (Storie 1933). The Storie Index is based on 3 characteristics and conditions of the soils. The first factor considers the characteristics of the profile, the parent material, the mode of soil formation, and the degree of profile development. The second factor considers the texture of the surface soil. The third factor considers the soil modifying conditions of drainage, pH, and fertility. Soils are assigned a percentage rating for each of the 3 factors, and the 3 values are multiplied to give the index rating for each soil type.

Data on the production aspects of each farm were gathered from direct interview of the individual farm operators. Units of operation were compared rather than units of ownership; operators might be owners, part-owners, or tenants. Information was collected about how the land on each farm was being utilized. Acreage totals per farm and percentage figures per farm were used to indicate how fully the land on each farm was being utilized for agricultural production. The types of crops grown were studied including acreage for each crop, yields, and fertilizer application rates per acre for each crop. In all, 8,220 acres on Wisconsin soils and 10,570 acres on Illinoian soils were analyzed regarding use.

The crop rotation system employed by each farm operator was evaluated using an index system used to measure the balance between favorable and unfavorable effects of a crop on the capacity of the soil to produce (Salter *et al* 1936). Values were adjusted for the amounts of commercial fertilizer applied per acre.

Land value per acre for each of the sample farms was secured from tax records at the county assessors office in both counties of the study area. The land value per acre used was the assessed value of land for tax purposes and was expected to reflect productivity levels and to compare favorably with the productivity guides in the county soil survey reports. Each of the above factors was examined using a one way unequal analysis of variance test conducted at a 0.01 level of significance.

RESULTS AND DISCUSSION

A number of relationships have been suggested as being a part of the influence of contrasting soil regions on agricultural types. In my study area, each of the implied relationships was examined to determine if there was a significant difference between the soil regions in their agricultural types and which factors contributed to such a difference.

The contrast in soil capabilities between the regions in the study area appears to be shown by the significant difference in the values of the Storie Index (1933). A value of 33.88 for the Illinoian age soil region compared to a value of 55.48 for the Wisconsin age soil region seems to indicate the variation in natural fertility and productive capacity between the 2 regions. The lack of significant difference in crop yields as discussed below, however, may cast some doubt on the importance of the Storie Index values.

Both soil regions require the use of artificial drainage: 92% of the study farms on Illinoian age soils and 100% of the study farms on Wisconsin age soils. In the Illinoian age region, however,

open-ditch drains are used on 88% of the farms, tile drains are used on 4% of the farms, and 8% of the farms have no organized drainage system, whereas in the Wisconsin age region, all of the farm operators use tile drains. The difference in drainage methods emphasizes the fragipan obstruction to drainage on the older soils.

The average farm size in the two soil regions was not significantly different for the sample group of farms in the study. The average size of 422.7 acres in the Illinoian age soil region and the average size of 329.2 acres in the Wisconsin age soil region were comparable to average farm sizes in this part of Ohio.

The relationship between the soil regions and allocation of land use may be stated as follows: a significantly greater percentage of farmland is devoted to cropland use on the Wisconsin age soils than on the Illinoian age soils (table 1).

TABLE 1
Land use allocation by soil region.

Soil Region	Wisconsin (%)	Illinoian (%)
Total Cropland as % of Farm	87.4	78.6*
Cropland Harvested as % of Cropland	82.6	75.1
Non-Cropland Pastured as % of Farm	8.8	12.6
Land not Tilled as % of Farm	7.7	8.4
Idle Land as % of Farm	3.9	3.5
Woodlots as % of Farm	3.4	9.4*
% of Woodlots Pastured	21.9	12.3
Average Farm Size—acres	329.2	422.7

*Significant difference ($P<0.01$).

In addition, a significantly greater percentage of each farm is in woodlots on the Illinoian age soils than on the Wisconsin age soils. The analysis of variance tests of the other uses of farmland indicated there is no significant difference between the adjacent soil regions in the percentage of cropland in crops, the percentage of cropland in pasture, the percentage of non-cropland in pasture, the percentage of farmland not tilled, the percentage of farmland idle or not used for agricultural production, and the percentage of woodland used for pasture (tables 1 and 2).

TABLE 2
*Level of significance of variables analyzed.**

Index of Productivity	<0.0005*
Balance of Crop Rotation	<0.0005*
Acreage in Farm	0.078
Value per Acre	<0.0005*
Livestock Units	0.063
% Cropland Corn	<0.0005*
Corn Yield	0.040
N on Corn	0.920
P on Corn	0.026
K on Corn	0.403
Total Corn Fertilizer	0.299
% Cropland Soybeans	<0.0005*
Soybean Yield	0.685
N on Soybeans	0.010 *
P on Soybeans	<0.0005*
K on Soybeans	<0.0005*
Total Soybean Fertilizer	<0.0005*
% Cropland Wheat and Oats	0.504
Wheat Yield	0.408
N on Wheat	0.214
P on Wheat	0.338
K on Wheat	0.147
Total Wheat Fertilizer	0.155
% Farm in Cropland	0.010 *
% Cropland in Crops	0.103
% Cropland in Pasture	0.304
% Non-Cropland in Pasture	0.240
% Farm Not Tilled	0.744
% Farm Idle	0.777
% Farm Woodlot	0.002 *
% Woodlot Pasture	0.326
% Cropland in Hay	0.517

*Variables that are significant ($P<0.01$). Significance was determined by analysis of variance.

The analysis of land use allocation in the 2 soil regions indicated a more complete utilization of land for agricultural production on the Wisconsin age soils and a less complete utilization of land for agricultural production on the Illinoian age soils. The relatively less intensive land use on the Illinoian age soils including more pasture land and a significantly greater percentage of land in woodlots suggested a more mixed farming type on these older soils compared to a more specialized farming type on the younger Wisconsin age soils.

The relationship between the soil regions and land value per acre was a significantly higher value of land per acre in the Wisconsin age soil region ($271 per acre) than in the Illinoian age soil region ($173 per acre). This difference indicates the generally greater natural fertility of the younger soil region (Garner *et al* 1973)

and the direct variance of land value per acre and agricultural productivity as suggested in earlier studies (Bushnell 1958 and Ottoson 1954).

The relationship between the soil regions and corn production indicated that a significantly greater percentage of cropland was devoted to corn in the Wisconsin age soil region than in the Illinoian age soil region (table 3). There was no significant variation between regions in corn yield or in the amounts of fertilizer applied to corn (table 4).

TABLE 3

Percentage of cropland devoted to crops and average livestock numbers by soil region.

Crops	Wisconsin	Illinoian
Corn	62.1	27.1*
Soybeans	17.3	56.3*
Wheat and Oats	15.3	13.0
Hay	5.2	3.3
Livestock Units	87.9	38.4

*Significant difference ($P<0.01$) as determined by analysis of variance.

Although the corn yields are not significantly different between the two soil regions at the 0.01 level of significance, the yields might be significantly different at a 0.05 level. Thus, it seems that higher yields can be achieved in the younger soil region rather than in the older soil region. The percentage of cropland planted to corn in the younger soil region showed the importance of corn in a corn-livestock agricultural type. Corn ranks as the first crop in the Wisconsin age soil region. The significantly smaller percentage of cropland planted to corn in the older soil region pointed to less importance for corn in a more mixed agricultural type in the Illinoian age soil region where corn ranks as the second crop.

TABLE 4

*Crop yields and fertilizer application rates.**

	Wisconsin	Illinoian
Corn bu/A	109.9	91.1
N on Corn	123.4	121.6
P on Corn	60.3	86.1
K on Corn	87.6	104.8
Total on Corn	271.2	312.4
Soybeans bu/A	38.9	36.0
N on Beans	3.2	8.4**
P on Beans	11.4	39.5**
K on Beans	11.4	63.3**
Total on Beans	26.9	111.2**
Wheat bu/A	44.3	42.4
N on Wheat	21.9	34.2
P on Wheat	34.8	42.8
K on Wheat	31.6	47.4
Total of Wheat	88.3	124.5

*(lbs/A) by soil region.
**Significant difference ($P<0.01$).

There is a close visual relationship between the corn belt and the extent of Wisconsin age glaciation in the Midwest (Rose 1936). This visual relationship indicated a close correlation between the soils and the importance of corn in the agricultural types of the 2 soil regions in Ohio. This relationship is supported by my findings that corn is of much greater importance on the younger soils.

The relationships between the soil regions and soybean production were a significantly greater percentage of cropland devoted to soybeans on the Illinoian age soils than on the Wisconsin age soils and significantly higher application rates of nitrogen, phosphorus, potassium, and total fertilizers on the older soils than on the younger soils (tables 3 and 4). The soybean yield was not significantly different between soil regions.

The significantly greater percentage of cropland planted to soybeans on the Illinoian age soils than on the Wisconsin age soils indicated the relatively greater importance of soybeans in a mixed agricultural type on the older soils and upheld the earlier findings that soybeans usurp acreage from other crops on "claypan" soils (Weaver 1954). Soybeans are well adapted to the poorer soils as a relatively profitable grain crop because they can be planted later in spring than corn, which helps overcome the spring wetness handicap on the "claypan" soils. Soybeans also resist the mid and later summer moisture deficiencies of the "claypan" soils better than corn. The significantly lower percentage of cropland planted to soybeans on the younger soils substantiated the lesser importance of soybeans in the corn-livestock agricultural type of the Wisconsin age soil region. Soybeans were the first rank crop on the older

soils and the second rank crop on the younger soils.

Greater fertilizer application rates on soybeans on the older soils than on the younger soils resulted in soybean yields that are similar to those on the younger soils (table 4). The similar yields in the 2 soil regions, despite significantly different fertilizer application rates, supported the contention that greater amounts of fertilizer are needed on the older soils than on the younger soils to produce similar results.

An analysis of the relationships between the soil regions and wheat and oat production showed no significant difference in yield, in the percentage of cropland planted to wheat and oats, and in fertilizer application rates (tables 3 and 4). The percentage of cropland devoted to wheat and oats was virtually the same in both soil regions. It appeared that wheat and oats have similar levels of importance in both soil regions, despite what seem to be different farming-type classifications for the 2 regions. Wheat was the third ranked crop in both soil regions. While the fertilizer application rates were not significantly different between the 2 soil regions, the somewhat larger amounts of fertilizer applied to the older soils seemed to be sufficient to produce yields comparable to yields on the younger soils (table 4).

The crop rotation systems used by farm operators in the 2 soil regions were evaluated using a "Productive Balance" (Salter *et al* 1936). A significantly greater amount of nutrients are removed from the soil by the rotations used on the Wisconsin age soils than by those used on the Illinoian age soils, as indicated by a balance of -1.05 on the younger soils and a balance of -0.48 on the older soils. The negative value in both regions indicated that farm operators in both regions are removing more nutrients from the soil in the process of crop production than are being replaced by fertilizers and by alfalfa or clover in the rotation.

The average number of livestock units per farm in the Wisconsin age soil region was not significantly greater than the average number of livestock units in the Illinoian age soil region (table 3). The average of 87.9 units on the younger soils, however, showed the importance of livestock in a corn-livestock agricultural type, and the average of 38.4 units on the older soils showed relatively less importance of livestock in a mixed agricultural type (table 5). The agricultural activities in both soil regions were analyzed by converting livestock and crop production to common units (Yeates 1968) and showed that the older soil region has soybean and corn production as the major agricultural activities, accounting for nearly 80% of the total activity. This soil region has been classed as a mixed farming agricultural type emphasizing soybeans. The younger soil region has corn and livestock production as the major agricultural activities, accounting for about 73% of the total activity. The younger soil region has been classed as a corn-livestock agricultural type emphasizing corn.

TABLE 5

Agricultural activity contributions (%) by soil region.

Illinoian		Wisconsin	
Soybeans	51.5	Corn	55.8
Corn	27.9	Livestock	17.6
Livestock	8.8	Soybeans	13.8
Others	11.8	Others	12.8

The modes of farming in any areas and the agricultural type developed from these modes is not a haphazard growth, but the result of farmers' efforts to adjust organization and operations to definite factors such as soils. The above analyses of the factors of agricultural production in relation to the contrasting adjacent soil regions indicate that soils help to set limits to agricultural production and play a role in the differences in agricultural types that can be classified in the Midwest and especially in Ohio. The differences in agricultural types between the soil regions were shown by the variations in the approach to farming by the individual farm operators, in the crops emphasized in the production process, and in the methods emphasized in producing these crops. The statistically significant variables make it reasonable to accept the premise that con-

trasting soils influence differences in the agricultural types of the soil regions in question.

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